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Designing Double Acceptance Sampling Plans Based on Truncated Life Tests in Rayleigh Distribution Using Minimum Angle Method

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Abstract In this paper double sampling plans for truncated life tests are developed using minimum angle method when the lifetimes of the items follows Rayleigh distribution. The values of operating ratio corresponding to the consumer's risk and producer's risk are calculated and using minimum angle method, the value θ is found. Tables are constructed and examples are provided. By applying Minimum angle method for Designing Double Acceptance Sampling Plans under Reliegh Distribution it is found to be more economic in saving cost, energy and time. It also minimizes the consumers and producers risk simultaneously.

Keywords Probability of Acceptance, Rayleigh Distribution, Producer's Risk, Consumer's Risk, Minimum Angle Method

1. Introduction

Acceptance sampling procedures play an important role in improving the quality. The basic aim of all companies in this world is to improve the quality of their products. The high quality product has the high probability of acceptance. In a time- truncated sampling plan, a random sample is selected from a lot of products and put on the test where the number of failures is recorded until the pre – specified time. If the number of failures observed is not greater than the specified acceptance number, then the lot will be accepted. Two risks are always attached to an acceptance sampling. The probability of rejecting the good lot is known as the type – 1 error (producer's risk) and it is denoted by α. The probability of accepting the bad lot is known as the type – 2 error (consumer's risk) and it is denoted by β. An acceptance sampling plan should be designed so that both risks are smaller than the required values. An acceptance sampling plan involves quality contracting on product orders between the producer's risk and consumer's risk.

These life tests are discussed by many authors Goode and Kao (1961).[1] Ayman Baklizi (2003),[2] Baklizi A,,El Qader, and El Masri (2004).[3] Rosaiah and Kantam (2005) [4] Tsai, Tzong and Shuo (2006).[5] and Mohammad Aslam [6] have designed double acceptance sampling plan based on truncated life tests in Rayliegh distribution. Srinivasa Rao[8] have designed double acceptance sampling plan based on truncated life tests for the Marshall – Olkin extended exponential distribution.

The intent of this paper is to design double sampling plans for truncated life tests using minimum angle method, when life times of the items follows Rayleigh distribution.

It is known that the double acceptance sampling plan (DASP) is more efficient than the single sampling plan in terms of the sample size required. Further, a DASP is expected to reduce the producer's risk when specifying the consumer's risk.

2. Operating Procedure for Double Sampling Plan

1) From a lot, take a first sample of size n_1 and observe the number of nonconforming units, d_1.

2) If $d_1 \leq c_1$, accept the lot; if $d_1 \geq c_2$, reject the lot. If $c_1 < d_1 < c_2$ take a second sample of size n_2 and observe the number of nonconforming units, d_2.

3) If $d_1 + d_2 \leq c_2$, accept the lot; otherwise reject the lot.

Thus the double sampling plan is characterized by the parameters n_1, n_2, c_1, c_2, and designated as DASP – (n_1, n_2, c_1, c_2).

3. Double Sampling Plans in Life Tests

We propose the following Double sampling plan procedure based on a truncated life test:

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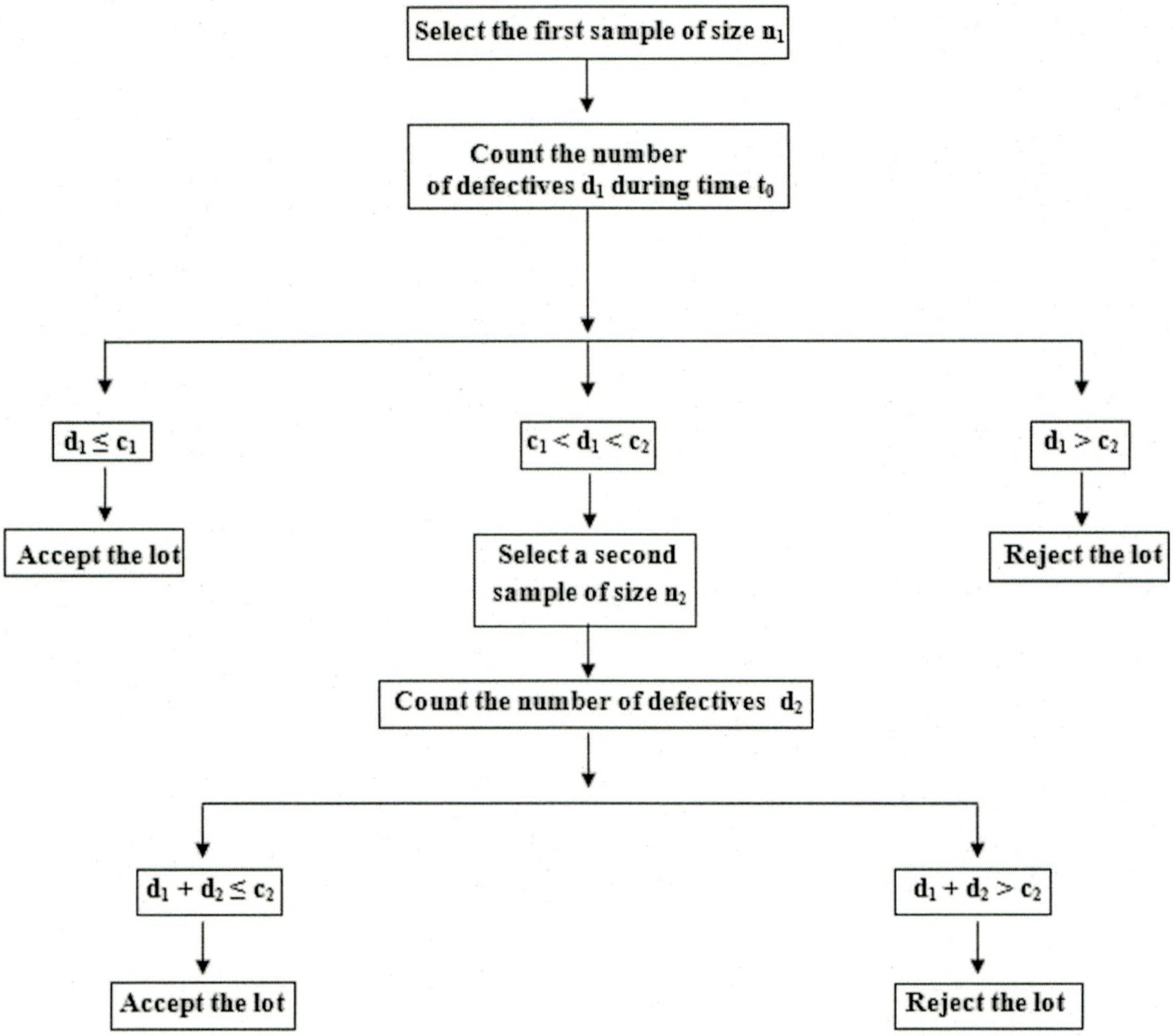
1. Draw the first sample of size n_1 and put them on test during time t_0
2. Accept the lot if there are no more than c_1 failures. Reject the lot and terminate the test if there are more than c_2 failures.
3. If the number of failures is between c_1 and c_2, then draw the second sample of size n_2 and put them on test during time t_0.
4. Accept the lot if the total number of failures not more than c_2 during the time t_0.

DECISION FLOWCHART FOR DOUBLE SAMPLING PLAN IN LIFE TESTS.



The DASP is composed of four parameters of (n_1, n_2, c_1, c_2) if t_0 is specified. Here n_1 and n_2 are sample sizes of the first and second sample, whereas c_1 and c_2 are the acceptance numbers associated with the first and the second sample, respectively. Let λ be the unknown average life and λ_0 be the specified average life. A lot is considered to be good if the true unknown average life is more than the specified average life.

We assume that the lot size is large enough to use the binomial distribution to find the probability of acceptance of the lot. In this paper we have considered $c_1 = 0$ and $c_2 = 2$, ie. DASP ($c_1 = 0$ and $c_2 = 2$).

Where, $P = F(t, \lambda) = F\left(\frac{t}{\lambda 0} * \frac{\lambda 0}{\lambda}\right)$ is the function CDF of the Rayleigh distribution and the Cumulative Distribution Function (CDF) is,

$$F(t,\lambda) = 1 - e^{-\frac{t}{\lambda}} \quad t>0, \lambda>0$$

Then,

$$P = 1 - e^{-\frac{1}{2}\left(\frac{t}{\lambda}\right)^2} \tag{1}$$

For different time ratio $t/\lambda_0 = 0.628, 0.942, 1.257, 1.571, 2.356, 3.141$ and different mean ratios $\lambda/\lambda_0 = 4, 6, 8, 10$ and 12, the cumulative distribution function of the Rayleigh distribution is calculated using the formula (1).The probability of acceptance $L(p_1)$ and $L(p_2)$ of DASP are calculated using above values. The probability of acceptance for DASP is given by P (A) = P (no failure occur in sample 1) + P (1 failure occur in sample 1 and 0, 1 failure occur in sample 2) + P (2 failures occur in sample 1 and 0 failure occurs in sample 2).

The probability of acceptance DASP (n_1, n_2, 0,2) is given in formula(2)

$$L(p) = \binom{n_1}{0} p^0 q^{n_1} + \binom{n_1}{1} p^1 q^{n_1-1}\left[\sum_{i=0}^{1}\binom{n_2}{i} p^i q^{n_2-i}\right] + \binom{n_1}{2} p^2 q^{n_1-2}\left[\left(\binom{n_2}{0} p^0 q^{n_2}\right)\right] \quad (2)$$

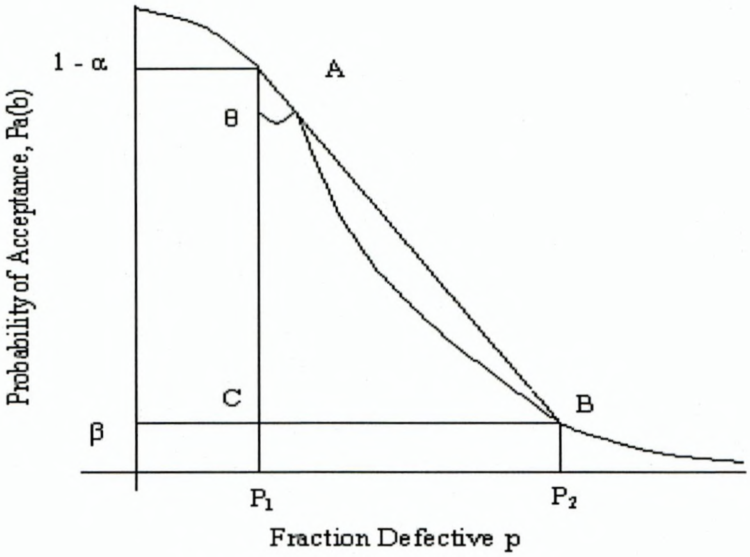


Figure 1. Minimal angle for given P_1 and P_2

4. Operating Characteristics Function

The probability of acceptance can be regarded as a function of the deviation of the unknown average life λ_0 from its specified average life λ. This function is called Operating Characteristic (OC) function of the sampling plan. For different time ratio t/λ_0 = 0.628, 0.942, 1.257, 1.571,2.356 and 3.141 the parameters n_1 and n_2 are determined using minimum angle method.

Notation:

n	Sample size
c	Acceptance number
t_0	Termination time
α	Producer's risk
β	Consumer's risk
P	Failure probability
L(p)	Probability of acceptance
λ	Mean life
λ_0	Specified life
θ	Minimum angle
n_1-	First sample size
n_2	Second sample size
c_1	Acceptance number of first sample
c_2	Acceptance number of second sample
d	Number of defectives

5. Minimum Angle Method

The practical performance of a sampling plan is revealed by it operating characteristic curve. Norman Bush et. al.[7] have used different techniques involving comparison of some portion of the OC curve to that of the ideal curve. The approach of minimum angle method by considering the tangent of the angle between the lines joining the points Acceptable Quality Level (AQL, 1- α) and Limiting Quality Level (LQL β) is shown in Figure 1, where p_1 = AQL, p_2 = LQL. By employing this method one can get a better discriminating plan with the minimum angle. Tangent of angle made by lines AB and AC is

$$\tan\theta = BC / AC$$

$$\tan\theta = (p_2 - p_1) / (Pa(p_1) - Pa(p_2)) \quad (3)$$

The smaller the value of this tan θ, closer is the angle θ approaching zero and the chord AB approaching AC, the ideal condition through (AQL, 1-α). This criterion minimizes simultaneously the consumer's and producer's risks. Thus both the producer and consumer favor the plans evolved by the criterion.

In this paper we design parameters of the double acceptance sampling plan based on truncated life tests for Rayleigh distribution, using minimum angle method. The minimum angle method of the double sampling plan under Rayleigh distribution for truncated life test is given below. Let us assume mean ratio λ/λ_0 (4,6,8,10,12) and the consumer's risk $\beta \leq .10$ and producer's risk α = 0.05 are specified. The probability of acceptance L (p_1) and L (p_2) is placed in Table 1 to Table 5 for c_1 = 0 and c_2 = 2 and the time ratios t/λ_0 = 0.628, 0.942, 1.257, 1.571,2.356, 3.141.

From the Tables 1, 2, 3, 4 and 5 it can be noted that from the given values for fixed mean ratio and various time ratios. We select the parameters corresponding to minimum angle.

Table 1. Minimum Angle Double Sampling Plan Under Rayleigh Distribution for $C_1 = 0$ & $C_2 = 2$

t/λ_0	λ/λ_0	n_1	n_2	$L(p_1)$	$L(p_2)$	$\tan\theta$	Θ
0.628	4	15	18	0.993478	0.083341	1.071839	46.98588
	4	14	18	0.99412	0.098354	1.089035	47.44048
	4	16	18	0.992804	0.070609	1.057825	46.60959
	4	17	18	0.992097	0.059813	1.046377	46.29826
	4	15	20	0.992526	0.074524	1.062656	46.7399
	4	14	20	0.993238	0.088528	1.078268	47.15676
	4	18	20	0.990192	0.044459	1.031496	45.88824
	4	16	20	0.991781	0.062737	1.050025	46.39786
	4	14	23	0.991828	0.078574	1.06818	46.88815
	4	15	23	0.991006	0.065608	1.054162	46.51038
	4	16	23	0.990151	0.054788	1.042932	46.20389
	4	19	23	0.987383	0.031925	1.020997	45.59525
	4	16	28	0.987204	0.047799	1.038444	46.08045
	4	22	28	0.980196	0.015397	1.011113	45.3166
	4	19	28	0.983854	0.027117	1.019632	45.55694
	4	13	28	0.990246	0.084331	1.076834	47.11873
	4	14	33	0.986474	0.065977	1.059775	46.66227
	4	18	33	0.981401	0.030407	1.02579	45.72939
	4	26	33	0.969628	0.006475	1.01284	45.3655
	4	15	33	0.985257	0.054357	1.047932	46.34077
	4	20	37	0.97528	0.019995	1.021182	45.60044
	4	25	37	0.967018	0.007532	1.016711	45.47475
	4	30	37	0.957947	0.002839	1.021372	45.60576
	4	12	37	0.986772	0.095487	1.09451	47.58359
	4	18	37	0.978354	0.029553	1.028161	45.7955
0.942	4	12	19	0.958175	0.004977	0.991716	44.7617
	4	10	19	0.966781	0.012037	0.990111	44.71529
	4	8	19	0.974747	0.02912	0.999656	44.99014
	4	7	19	0.978486	0.045297	1.01298	45.36945
	4	12	21	0.95276	0.004919	0.997321	44.92316
	4	9	21	0.966696	0.018566	0.997018	44.91443
	4	7	21	0.975221	0.045016	1.01623	45.46122
	4	6	21	0.979246	0.070099	1.039767	46.1169
	4	15	17	0.950566	0.00137	0.995897	44.88222
	4	13	17	0.959308	0.003293	0.988794	44.67716
	4	9	17	0.974857	0.019067	0.989027	44.6839
	4	11	17	0.967412	0.007922	0.985213	44.57323
1.257	4	4	18	0.956538	0.042425	0.988549	44.67008
	4	3	18	0.967933	0.093479	1.033384	45.94058
	4	5	13	0.964292	0.019329	0.956277	43.71964
	4	6	13	0.95569	0.00878	0.95431	43.66073
	4	3	13	0.980067	0.953753	34.3412	88.33204
	4	3	11	0.02468	0.965204	0.444178	23.94972
	4	3	9	0.024741	0.951283	0.450881	24.26971
	4	4	9	0.007211	0.9547	0.440913	23.79329
2.356	4	2	4	0.9547	0.004006	0.716845	35.63465
	4	2	3	0.971501	0.005403	0.705415	35.19972

Table 2. Minimum Angle Double Sampling Plan Under Rayleigh Distribution for $C_1 = 0$ & $C_2 = 2$

t/λ_0	λ/λ_0	n_1	n_2	$L(p_1)$	$L(p_2)$	$\tan\theta$	Θ
0.628	6	16	24	0.998893	0.052933	1.045577	46.27639
	6	20	24	0.998445	0.025547	1.016627	45.47238
	6	15	24	0.998993	0.063524	1.057303	46.59548
	6	18	24	0.998678	0.036766	1.028237	45.79762
	6	15	28	0.998735	0.05779	1.051149	46.42849
	6	13	28	0.998961	0.08438	1.081451	47.24094
	6	17	28	0.99849	0.039596	1.031473	45.8876
	6	25	28	0.997306	0.008759	1.000534	45.01529
	6	18	40	0.997234	0.02923	1.021766	45.61682
	6	24	40	0.995915	0.009015	1.002203	45.06303
	6	30	40	0.994379	0.002782	0.997455	44.92701
	6	35	40	0.992927	0.001045	0.997168	44.91877
0.942	6	18	22	0.988949	0.000344	0.986746	44.61777
	6	14	22	0.992294	0.002021	0.985084	44.5695
	6	17	22	0.989836	0.000535	0.986052	44.59763
	6	16	22	0.990689	0.000833	0.9855	44.58157
	6	15	29	0.987647	0.001288	0.988993	44.68293
	6	18	29	0.984274	0.00034	0.99143	44.75344
	6	13	29	0.989724	0.003128	0.988754	44.67602
	6	24	29	0.976601	0.0001	0.998899	44.96843
	6	21	37	0.973644	0.0001	1.002	45.05725
	6	25	37	0.966958	0.0001	1.008852	45.25248
	6	30	37	0.957871	0.0001	1.018408	45.52253
	6	28	37	0.961601	0.0001	1.01446	45.41126
1.257	6	9	18	0.985087	0.000817	0.971876	44.18286
	6	13	18	0.975675	0.0001	0.980472	44.43507
	6	16	18	0.967484	0.0001	0.988741	44.67563
	6	11	18	0.980598	0.000168	0.975683	44.29483
	6	16	20	0.963315	0.0001	0.99302	44.79934
	6	8	20	0.996836	0.028994	1.007915	45.22585
	6	12	20	0.975039	0.0001	0.981153	44.45496
	6	14	20	0.969386	0.0001	0.986813	44.61973
	6	6	20	0.989436	0.008738	0.975415	44.28697
	6	7	25	0.982363	0.003965	0.977709	44.35423
	6	12	25	0.966688	0.0001	0.98963	44.70139
	6	15	25	0.956095	0.0001	1.000524	45.01499
	6	10	25	0.994076	0.011851	0.993156	44.80325
	6	8	17	0.963225	0.0001	0.968262	44.07619
	6	6	17	0.973891	0.000609	0.958205	43.77729
	6	4	17	0.983589	0.007183	0.955139	43.68558
	6	11	14	0.956572	0.0001	0.974946	44.27318
	6	5	14	0.984123	0.002091	0.949668	43.5212
	6	7	14	0.975958	0.000177	0.955752	43.70392
	6	5	7	0.994322	0.002194	0.940004	43.22866
	6	3	7	0.997249	0.025327	0.959546	43.81732
2.356	6	4	8	0.958511	0.0001	0.888481	41.62049
	6	3	8	0.97075	0.000242	0.877485	41.26645

Table 3. Minimum Angle Double Sampling Plan Under Rayleigh Distribution for $C_1 = 0$ & $C_2 = 2$

t/λ_0	λ/λ_0	n_1	n_2	$L(p_1)$	$L(p_2)$	$\tan\theta$	Θ
0.628	8	13	22	0.999873	0.097286	1.101262	47.75901
	8	15	22	0.999843	0.068163	1.066875	46.85318
	8	18	22	0.999791	0.040004	1.035631	46.00278
	8	20	22	0.999752	0.02805	1.022933	45.64949
	8	21	27	0.999646	0.019122	1.013729	45.39062
	8	25	27	0.999531	0.009051	1.003538	45.10119
	8	17	27	0.999743	0.040459	1.036173	46.01777
	8	14	27	0.999806	0.071056	1.070239	46.94319
	8	22	37	0.999403	0.013542	1.00824	45.23508
	8	17	37	0.999584	0.035956	1.031502	45.8884
	8	28	37	0.999146	0.004199	0.999033	44.97228
	8	32	37	0.998949	0.001925	0.996952	44.91254
0.942	8	9	18	0.999382	0.01886	1.005773	45.16491
	8	12	18	0.999065	0.005029	0.992099	44.77277
	8	15	18	0.998683	0.001342	0.988811	44.67766
	8	13	22	0.998591	0.003148	0.990697	44.73224
	8	16	22	0.99809	0.000833	0.988895	44.6801
	8	8	22	0.999271	0.028853	1.016244	45.46161
	8	11	22	0.998886	0.007636	0.994888	44.85318
	8	17	28	0.997075	0.00053	0.989601	44.70054
	8	12	28	0.998182	0.004875	0.992827	44.79377
	8	21	28	0.996027	0.0001	0.990205	44.71802
	8	25	28	0.994826	0.0001	0.991326	44.75042
	8	22	37	0.993808	0.0001	0.992384	44.78099
1.257	8	17	37	0.99562	0.00053	0.991048	44.7424
	8	9	37	0.998009	0.018442	1.006753	45.1928
	8	30	37	0.990374	0.0001	0.995769	44.87854
	8	28	37	0.991295	0.0001	0.994846	44.85196
	8	7	15	0.999674	0.04728	1.035477	45.99854
	8	11	15	0.999369	0.008324	0.995092	44.85906
	8	9	15	0.999534	0.019827	1.006609	45.18872
	8	10	15	0.997195	0.000371	0.978572	44.37952
	8	8	15	0.99796	0.001802	0.979226	44.39865
	8	5	15	0.998907	0.01927	0.99574	44.87771
	8	12	15	0.996316	0.0001	0.979147	44.39632
	8	14	23	0.991777	0.0001	0.983567	44.52534
	8	17	23	0.989197	0.0001	0.986119	44.59955
	8	8	23	0.996044	0.0018	0.981111	44.45372
1.571	8	17	23	0.989197	0.0001	0.986119	44.59955
	8	19	35	0.978331	0.0001	0.99707	44.91593
	8	13	35	0.986488	0.0001	0.98886	44.67907
	8	26	35	0.967281	0.0001	1.00846	45.24133
	8	12	35	0.987729	0.0001	0.987659	44.64427
	8	10	19	0.986854	0.0001	0.974622	44.26368
	8	7	19	0.991647	0.000177	0.970081	44.12993
	8	15	19	0.977191	0.0001	0.984256	44.54541
	8	12	19	0.983241	0.0001	0.9782	44.36861
	8	14	25	0.970718	0.0001	0.990819	44.73578
	8	9	25	0.983009	0.0001	0.978446	44.37581
	8	11	25	0.978335	0.0001	0.983106	44.51191
	8	18	25	0.95945	0.0001	1.002455	45.07026
	8	20	25	0.953353	0.0001	1.008866	45.25288
2.356	8	9	12	0.951088	0.0001	0.962187	43.89599
	8	6	12	0.971022	0.0001	0.942434	43.30248
	8	4	12	0.982324	0.0001	0.931606	42.97211
	8	10	12	0.943684	0.0001	0.969735	44.11973
	8	5	15	0.968295	0.0001	0.945089	43.38294
	8	6	15	0.960832	0.0001	0.952429	43.60426
	8	4	15	0.975394	0.0001	0.938224	43.17447
	8	3	15	0.98212	0.000242	0.932014	42.98465
	8	5	20	0.953085	0.0001	0.960171	43.83597
	8	7	20	0.932458	0.0001	0.981411	44.46247
	8	3	20	0.972693	0.000242	0.941049	43.26042

Table 4. Minimum Angle Double Sampling Plan Under Rayleigh Distribution for $C_1 = 0$ & $C_2 = 2$

t/λ_0	λ/λ_0	n_1	n_2	$L(p_1)$	$L(p_2)$	$\tan\theta$	Θ
0.628	10	14	17	0.999972	0.104615	1.112472	48.04766
	10	15	17	0.999969	0.088966	1.093366	47.55376
	10	18	23	0.999936	0.038252	1.035746	46.00595
	10	16	23	0.999946	0.05483	1.053902	46.5033
	10	20	23	0.999924	0.026695	1.023459	45.66424
	10	25	27	0.999863	0.009051	1.005297	45.15134
	10	23	27	0.999881	0.013154	1.009459	45.26969
	10	20	27	0.999905	0.023059	1.01967	45.558
	10	17	27	0.999926	0.040459	1.038139	46.07204
0.942	10	14	21	0.999591	0.002029	0.993568	44.81514
	10	12	21	0.999675	0.004919	0.996371	44.89585
	10	8	21	0.999814	0.028909	1.020848	45.59107
	10	18	21	0.999397	0.000345	0.992087	44.77242
	10	15	21	0.999546	0.001303	0.99289	44.7956
	10	20	27	0.998998	0.00014	0.992279	44.77796
	10	17	27	0.999214	0.000531	0.992453	44.78297
	10	14	27	0.999405	0.002008	0.993733	44.8199
	10	24	27	0.998669	0.0001	0.99249	44.78406
1.257	10	18	21	0.996902	0.0001	0.987322	44.63448
	10	13	21	0.998096	0.0001	0.986174	44.60115
	10	8	21	0.999019	0.0018	0.987006	44.62532
	10	5	21	0.999454	0.019253	1.004143	45.11843
	10	22	28	0.993908	0.0001	0.990295	44.72061
	10	17	28	0.995801	0.0001	0.988414	44.66615
	10	12	28	0.99738	0.0001	0.986923	44.62292
	10	9	28	0.998183	0.000817	0.986861	44.62111
	10	30	37	0.986386	0.0001	0.997846	44.93823
	10	27	37	0.988294	0.0001	0.995921	44.8829
	10	23	37	0.99064	0.0001	0.993562	44.81496
	10	16	37	0.994217	0.0001	0.989991	44.71182
	10	11	37	0.99637	0.000168	0.988015	44.65459
	10	8	37	0.997507	0.0018	0.988506	44.66881
1.571	10	17	19	0.991512	0.0001	0.983823	44.53278
	10	14	19	0.993651	0.0001	0.981705	44.47105
	10	10	19	0.996053	0.0001	0.979342	44.40203
	10	8	19	0.997069	0.0001	0.978391	44.3742
	10	22	25	0.982613	0.0001	0.992732	44.79104
	10	19	25	0.985936	0.0001	0.989387	44.69434
	10	14	25	0.990785	0.0001	0.984545	44.5538
	10	12	25	0.992487	0.0001	0.982857	44.50465
	10	7	25	0.996165	0.000177	0.979402	44.40378
	10	25	34	0.970035	0.0001	1.005605	45.16013
	10	21	34	0.976248	0.0001	0.999205	44.97722
	10	17	34	0.981921	0.0001	0.993432	44.81122
	10	8	34	0.992697	0.0001	0.982699	44.50006
	10	15	17	0.993901	0.0001	0.981458	44.46384
	10	12	17	0.99564	0.0001	0.979744	44.41379
	10	7	17	0.997933	0.000177	0.977666	44.35299
	10	4	17	0.99897	0.007183	0.983549	44.52482
2.356	10	12	21	0.952663	0.0001	0.992225	44.77639
	10	8	21	0.970975	0.0001	0.973512	44.23103
	10	5	21	0.983075	0.0001	0.961531	43.87647
	10	6	15	0.987308	0.0001	0.957407	43.75346
	10	4	15	0.992212	0.0001	0.95269	43.61209
	10	9	15	0.978657	0.0001	0.96587	44.00539
	10	4	10	0.995954	0.0001	0.94911	43.50439
	10	3	10	0.997187	0.000242	0.948153	43.47553
	10	5	10	0.994564	0.0001	0.950423	43.54393

Table 5. Minimum Angle Double Sampling Plan Under Rayleigh Distribution for $C_1 = 0$ & $C_2 = 2$

t/λ_0	λ/λ_0	n_1	n_2	$L(p_1)$	$L(p_2)$	Tanθ	Θ
0.628	12	21	24	0.99997	0.021298	1.018997	45.53909
	12	17	24	0.999979	0.044112	1.043309	46.21423
	12	13	24	0.999986	0.091524	1.09775	47.66791
	12	12	24	0.999987	0.109881	1.120387	48.24955
	12	25	27	0.999953	0.009051	1.006421	45.18334
	12	22	27	0.999962	0.015859	1.013374	45.38058
	12	18	27	0.999972	0.033541	1.031904	45.89956
	12	14	27	0.999981	0.071056	1.073568	47.03194
	12	35	39	0.999867	0.001052	0.998447	44.95549
	12	31	39	0.999891	0.002301	0.999674	44.99065
	12	26	39	0.999917	0.006122	1.003491	45.09984
	12	22	39	0.999935	0.013397	1.010873	45.30979
	12	17	20	0.999984	0.052856	1.052936	46.47706
	12	13	20	0.999989	0.105233	1.114565	48.10119
	12	15	20	0.999987	0.074578	1.077647	47.14031
	12	19	20	0.99998	0.037459	1.036095	46.01561
0.942	12	18	21	0.99979	0.000345	0.9944	44.83912
	12	16	21	0.999826	0.000837	0.994854	44.85219
	12	11	21	0.999901	0.007658	1.001618	45.04631
	12	8	21	0.999936	0.028909	1.023502	45.66544
	12	24	26	0.999555	0.0001	0.994314	44.83666
	12	20	26	0.999667	0.00014	0.994318	44.83677
	12	17	26	0.999741	0.000531	0.994634	44.84587
	12	13	26	0.999824	0.003131	0.997145	44.91809
	12	30	37	0.998987	0.0001	0.994857	44.85229
	12	26	37	0.999186	0.0001	0.994667	44.84682
	12	22	37	0.999364	0.0001	0.994538	44.84311
	12	15	37	0.999625	0.001287	0.995503	44.87087
	12	9	37	0.999803	0.018442	1.012724	45.3622
1.257	12	16	20	0.999138	0.0001	0.989915	44.70961
	12	13	20	0.999372	0.0001	0.989714	44.7038
	12	8	20	0.999682	0.0018	0.991157	44.74553
	12	4	20	0.999866	0.042422	1.033019	45.93049
	12	23	26	0.997841	0.0001	0.991198	44.74672
	12	19	26	0.998392	0.0001	0.990651	44.73092
	12	14	26	0.998968	0.0001	0.990095	44.71484
	12	6	26	0.999654	0.008737	0.998125	44.94623
	12	27	35	0.995942	0.0001	0.993088	44.8013
	12	20	35	0.997368	0.0001	0.991668	44.76031
	12	15	35	0.998217	0.0001	0.990832	44.73614
	12	8	35	0.999184	0.0018	0.991652	44.75984
1.571	12	16	20	0.996959	0.0001	0.985932	44.59413
	12	13	20	0.997769	0.0001	0.985132	44.57088
	12	9	20	0.998665	0.0001	0.984263	44.54559
	12	21	25	0.993863	0.0001	0.989004	44.68324
	12	18	25	0.99512	0.0001	0.987754	44.64702
	12	12	25	0.997233	0.0001	0.985661	44.58627
	12	6	25	0.998844	0.000609	0.984672	44.5575
	12	25	30	0.989996	0.0001	0.992866	44.7949
	12	21	30	0.992236	0.0001	0.990625	44.73017
	12	15	30	0.995118	0.0001	0.987756	44.64708
	12	8	30	0.997789	0.0001	0.985163	44.57178
	12	4	30	0.999001	0.007183	0.991043	44.74224
2.356	12	9	12	0.993979	0.0001	0.967649	44.05805
	12	6	12	0.996619	0.0001	0.965085	43.98209

	12	3	12	0.998605	0.000242	0.9634	43.93205
	12	14	18	0.980652	0.0001	0.980798	44.44459
	12	11	18	0.986152	0.0001	0.975328	44.28442
	12	7	18	0.992313	0.0001	0.969273	44.10607
	12	4	18	0.996074	0.0001	0.965627	43.99818
	12	19	21	0.964258	0.0001	0.997474	44.92755
	12	16	21	0.971882	0.0001	0.989649	44.70193
	12	12	21	0.980896	0.0001	0.980554	44.43747
	12	7	21	0.99029	0.0001	0.971253	44.1645
3.141	12	9	12	0.972634	0.0001	0.958889	43.79771
	12	6	12	0.984108	0.0001	0.947709	43.46213
	12	4	12	0.990438	0.0001	0.941652	43.27874
	12	11	15	0.953011	0.0001	0.978633	44.38128
	12	8	15	0.968841	0.0001	0.962643	43.90955
	12	3	15	0.990235	0.0001	0.941846	43.28462

6. Designing DSP Based on Truncated Life Tests for the Rayleigh Distribution Using Minimum Angle Method

First let us fix the value of time ratio t/λ_0 and mean ratio λ/λ_0 corresponding to $c_1 = 0$ and $c_2 = 2$. Where the mean ratio $\lambda/\lambda_0 = 2,4,6,8,10$ and 12 be the acceptable reliability level (ARL) at the producer's risk and the mean ratio λ/λ_0 which is equal to 1, be the Lot Tolerance Reliability Level (LTRL) at the consumer's risk.

♦ The parameters n_1 & n_2 can be obtained from the table along with producers and consumers risk.

♦ First select the time ratio the t/λ_0

♦ Select the parameter of the sampling plan corresponding to smallest value of θ.

♦ Construction of Tables

The Tables are constructed using OC function for Double sampling plans under Rayleigh distribution is given by the equations (1), (2) & (3). Using the above values the minimum angle tan θ is calculated using the equation (3). For various time ratios t/λ_0 and mean ratios λ/λ_0 the parameter values n_1 and n_2 are obtained by DASP under Rayleigh Distribution for $c_1 = 0$ and $c_2 = 2$ and are presented in Table 1 to Table 5. Numerical value in these tables reveals the following facts.

For given mean ratio and time ratio $c_1 = 0$ and $c_2 = 2$, values in Tables 1-5 can be used to select the parameters of Double sampling plan under Rayleigh distribution for certain specified values of AQL and LQL. The parameters n_1, n_2 and θ can be obtained from the selected table corresponding to λ/λ_0 along with producer's risk and consumer's risk.

Example 1: Suppose one wants to design Double sampling plan under Rayleigh distribution for given $\alpha = .02$, $\beta = .01$, $\lambda/\lambda_0 = 4$, given $t/\lambda_0 = 0.628$, $c_1 = 0$, $c2 = 2$. From Table 1, one can observe that the minimum angle is $\theta = 45.3166°$ it corresponds to $n_1 = 22$ $n_2 = 28$. Thus the required sampling plan has parameters (22, 28, 0, 2).

Example 2: For given $\lambda/\lambda_0 = 6$, $\alpha = 0.007$, $\beta = 0.001$ from Table 2, one can observe the minimum angle is $\theta = 44.91877^0$. It corresponds to $n_1 = 35$ $n_2 = 40$. Thus the required sample plan has parameters (35, 40, 0, 2).

Example 3: For given $\lambda/\lambda_0 = 8$, $\alpha = 0.001$, $\beta = 0.002$ from Table 3, one can observe the minimum angle is $\theta = 44.91254^{\circ}$. It corresponds to $n_1 = 32$ $n_2 = 37$. Thus the required sample plan has parameters (32, 37, 0, 2).

Example 4: For given $\lambda/\lambda_0 = 10$, $\alpha = 0.001$, $\beta = 0.009$ from Table 4, one can observe the minimum angle is $\theta = 45.15134^0$. It corresponds to $n_1 = 25$ $n_2 = 27$. Thus the required sample plan has parameters (25, 27, 0, 2).

Example 5: For given $\lambda/\lambda_0 = 12$, $\alpha = 0.0002$, $\beta = 0.071$ from Table 5, one can observe the minimum angle is $\theta = 44.99549^0$. It corresponds to $n_1 = 35$ $n_2 = 39$. Thus the required sample plan has parameters (35, 39, 0, 2).

7. Conclusions

In this paper designing of double sampling plan for truncated life tests by using minimum angle method is presented. It is assumed that life times of the items follow Rayleigh distribution. It can be seen that by applying minimum angle method there is a great reduction in the sample sizes and at the same time this criterion minimizes simultaneously the consumer's and producer's risk. This minimum angle method plan provides better discrimination of accepting good lots

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